FACTORS INFLUENCING THE DEMAND FOR FERTILIZER IN SOUTH AFRICA: AN APPLICATION OF COMMODITY MODELLING

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INTRODUCTION

Following the process of deregulation and liberalisation in South African agriculture it is now more than evident that South African policy makers, trade negotiators, farmers and agribusinesses need a more permanent institution to facilitate informed decision making through improved analytical capabilities. For this reason the University of Pretoria (UP) has recently established a unit within the Department of Agricultural Economics to provide a long-term analytical capacity for policy analysis and business/market intelligence for the South African agricultural and food sector.

The purpose of this paper is to provide a brief overview of the system of commodity modelling that were introduced at Pretoria University and how it can be used to provide valuable business intelligence for farmers, agribusiness and government in South Africa. We will then illustrate the value of such analytical work by applying the techniques to the fertilizer industry. In the process we will indicate the value added generated by the South African fertilizer industry, the major factors influencing the demand for fertilizer and then finally we will provide a market outlook for the fertilizer industry until 2005.

AN AGRIBUSINESS INTELLIGENCE SYSTEM FOR SOUTH AFRICA

The overall objective of this newly established unit at UP is to develop and maintain a system of econometric models for the major crop, dairy and livestock sectors of the Republic of South Africa. It will at a later stage also include a series of multisector (CGE) models to analyse the economy wide impact of changes in the agricultural and rural sector. The models will provide a system of economic intelligence on agricultural markets as well as a barometer to measure the impact of policy and market changes on the agricultural sector. The agribusiness intelligence system has as its objectives to:

- Generate reliable and useful projections of likely agricultural markets outcomes under alternative scenarios.
- Build institutional capacity to conduct economic analysis that will be useful to decision makers.
- Coordinate and utilise a facilitating panel of South African policy makers and representatives of the agribusiness and academic communities to evaluate longer-term projections and identify for policy analysis, policy options of greatest interest to the South African agricultural sector.
- Develop an academic program in econometric modelling of the agricultural sector at the Department of Agricultural Economics, University of Pretoria which would contribute to building policy analysis capacity of students (mainly from previously disadvantaged groups) and government staff on a continuous basis.

The models of the agricultural sector will provide the opportunity to simulate the impact of policy changes and external influence such as world market changes on domestic prices, demand, supply, farm income and other important socio-economic variables. This is of particular importance for South Africa where the social and economic contribution of the agricultural sector to the economy is considerable. **Policy and business decisions** can now be assessed using a range of ***"what if"*** questions. The models will give a best estimate about the likely outcome of a particular policy proposal for farm incomes, competitiveness, employment, poverty levels, etc.

What will such a system achieve?

This system of modelling and analytical activity is designed to address some of the most pressing information needs facing policy makers, farmers and agribusinesses in South Africa. A system of econometric models using historical information about agricultural commodity markets will be estimated and will generate projections for future market outlooks under alternative scenarios.

The state of agricultural markets affects everything from the income of farmers to the trade balance. Reliable estimates of the quantitative impacts of policy alternatives can help government officials develop policies that will achieve desired objectives. Projections of the outlook for agricultural commodity markets under various scenarios can help farmers and businesses make better production and investment decisions.

The particular questions to be investigated will be determined according to the developments in markets and changes in policies. Regional negotiations such as the SADC free trade protocol and the international trade negotiations of the World Trade Organization and the European Union/RSA trade agreement are likely to suggest questions for an in depth analysis. Other questions are likely to arise from domestic economic policies and from the evolution of world commodity markets. Also there is no doubt that deregulation and trade liberalisation signal change in market orientation from the supplier to the consumer. The implications of these changes call for economic analysis that requires econometric modelling.

While the system is intended to generate specific outputs (e.g., the data base, models, and markets projections), it is also intended to encourage a process, which will encourage the establishment of formal and informal networks among researchers and industry specialists. Links to policy makers should ensure that the most relevant questions are investigated and that the analyses contribute to the policy process.

Currently no such formal econometric system similar to the one to be created exists in South Africa. Though few works on crop econometric models have appeared in the professional journals, these were intended to answer very specific questions.

The information generated by this initiative will be useful for domestic and international agribusiness firms to plan investment in South African agriculture.

Methodology

The following methodology was adopted for different agricultural commodities:

1) For each commodity, the important components of supply and demand will be identified. For a typical crop, those components might include the area devoted to production, the yield per hectare, total production, direct human consumption, industrial use, exports, imports, and ending stocks.
2) For each of the component of supply and demand, behavioural equations will be specified and the parameters estimated utilising econometric techniques.
3) Although a single-equation approach may be used for initial estimation, considerable emphasis will be placed on ensuring cross-equation and cross-commodity consistency. Supply equations, for example must properly reflect competition for land and other resources.
4) Special care will be taken to ensure that policy variables are correctly incorporated in the model to reflect the fundamental structure of the agricultural commodity market.
5) The principal objective is to develop a model that generates the best possible estimates of market outcomes under alternative scenarios. While econometric techniques will be used where feasible and appropriate, it may be necessary to obtain model parameters using other techniques in some cases, such as mathematical programming, expert judgement, and other approaches.

The models will be designed so as to simulate the intra- and extra-sectoral effects of policy changes, and the implications for the major macroeconomic aggregates. **Trade effects** will be emphasised because of the importance of the balance of payments. An important aspect of the extra-sectoral dimension of the research will be the explicit recognition of the integration of agriculture within a wider food system. Research in the USA and UK has indicated that when analysing agricultural policies, and the performance of the agricultural sector, it is important to do so within the context of the wider food system, and in particular to incorporate details about (downstream) food processing activities.

The models will provide *ex ante* estimates of the impact of policy changes. The simulation exercises will produce estimates of the implications for rural employment, production and consumption by commodity and sector, poverty alleviation and the major macroeconomic aggregates. Concern as to the (economic) sustainability of agricultural policy reforms will be assessed through the impacts of the reforms upon farm incomes, government budgets and balance of payments. This will identify potential constraints upon the effectiveness of policy changes.

Farm level analysis:

In evaluating these policies one of the critical social sustainability questions is the likelihood of financial survivability at the farm level. Evaluating farm income at a national level will be one issue, but the various policies adopted by South Africa will ultimately play out on individual farms.

One approach which has been successfully utilised elsewhere in helping to determine how the policies will work on the farm is to develop a set of farm-level models, linked to the kind of sector-wide models described earlier in this proposal. These farm models are structured to incorporate information on tax and other government policies, as well as dealing with the weather and other risk factors associated with production agriculture. Input data comes from either survey information or from producer panels.

A CASE STUDY: MODELLING THE FERTILIZER MARKET IN SOUTH AFRICA

The role of fertilizer in the agricultural sector has been widely recognised and is well documented. However, in the case of South Africa a very limited number of studies have been done so far to understand the factors influencing fertilizer use. This may be due to difficulties in gathering appropriate data and may be partly to the inadequacies of methodological procedures for

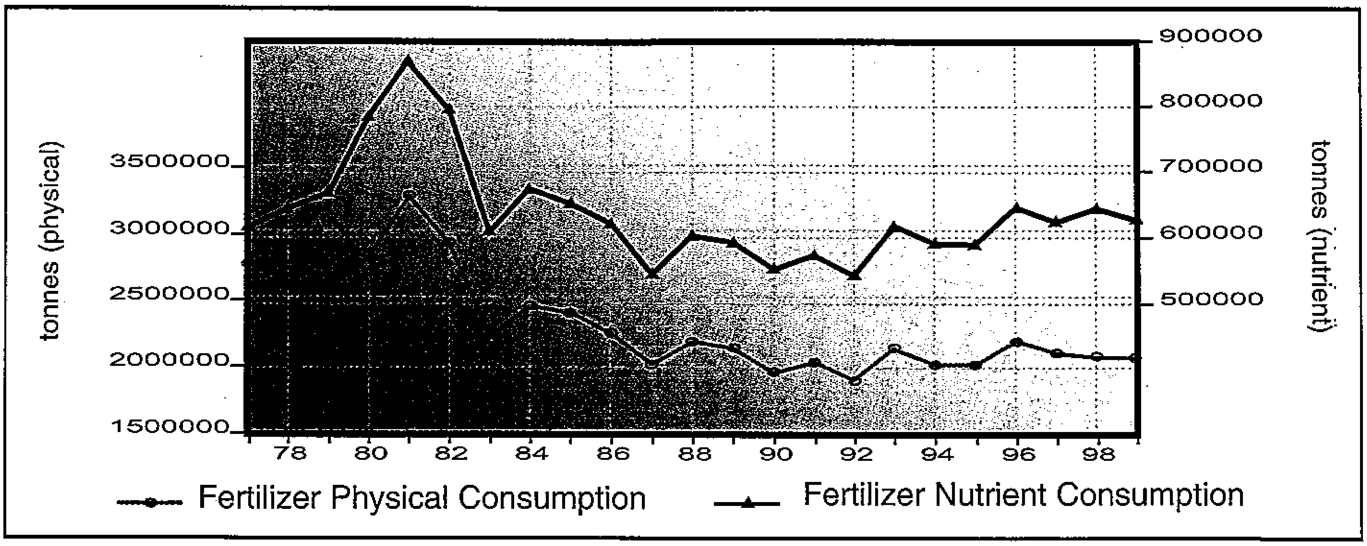

Figure 1. Fertilizer use in Physical (FPHT) and Nutrient Tonnage (FNT)

estimating demand function. Therefore, there is insufficient knowledge in understanding the economic contribution of fertilizer to the agricultural sector. Several studies have attempted to analyse how factor inputs have substituted each other. In a series of studies Van Zyl (1986a, 1986b,), Van Zyl and Groenewald (1988), and Poonyth and Van Zyl (2000), proposed and used the duality approach to evaluate the flexibly of input substitution for the South African agricultural sector. Another common approach is to estimate the parameters of behavioural equations such as demand, supply and investment functions. These estimates are thought to be useful for a wide range of problems, analysis of proposed policy, market environment, evaluation of existing policies, forecasting and improving the understanding of the economics of the sector.

In applying the methodology referred to earlier we will review the use of fertilizer and the value added component of fertilizer and estimate robust parameter of economic factors which influences fertilizer use at national level. The results of this paper will provide an understanding of the economics governing fertilizer use.

Background of Fertilizer Use in South Africa.

In the 1970s and early 1980s farmers benefited from subsidies in both the input and output sectors. Among others fertilizers, in fact, were not only subsidised, but also had a price ceiling. As of first of January 1984 all price controls on fertilizers, with exception of raw rock phosphate, were lifted. The reason being that with the tariffs and import controls, the industry did not have a comparative advantage on the international market.

Fertilizer use has been decreasing **(Figure 1)** due to decrease in area cropped **(Figure 3)** but yields for certain crops such as maize and wheat **(Figure 2)** have increased in the recent past. A rough indication from the

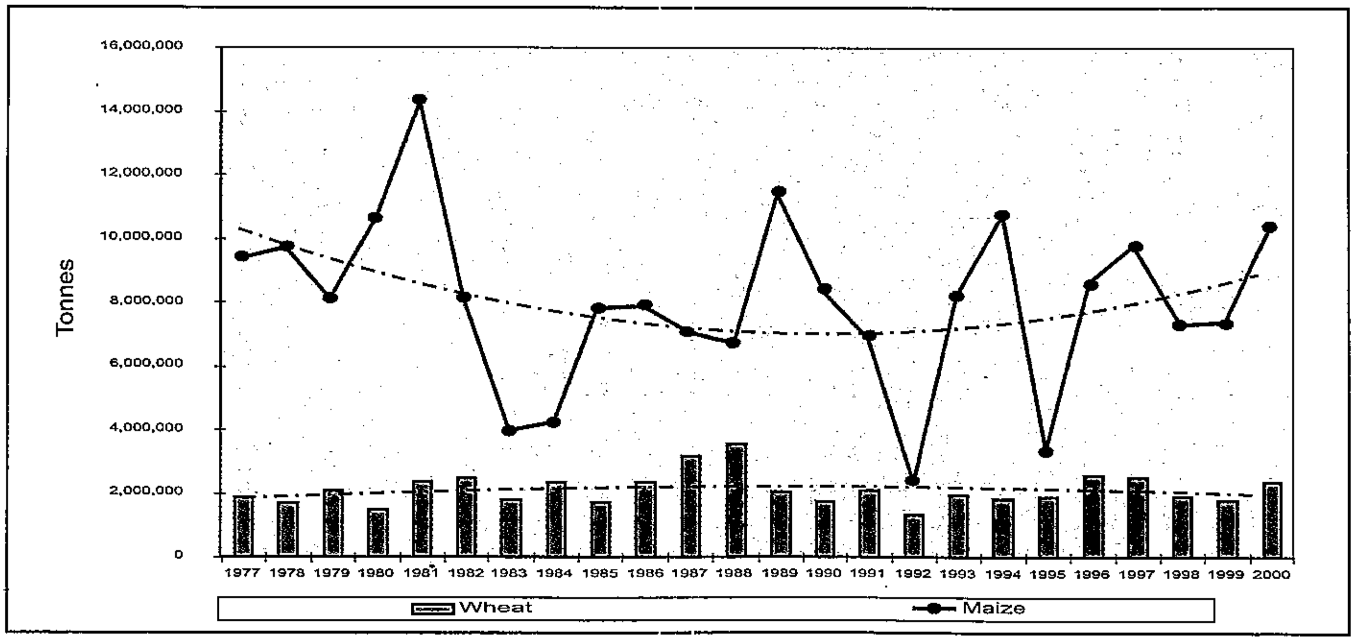

Figure 2. Maize and wheat total production

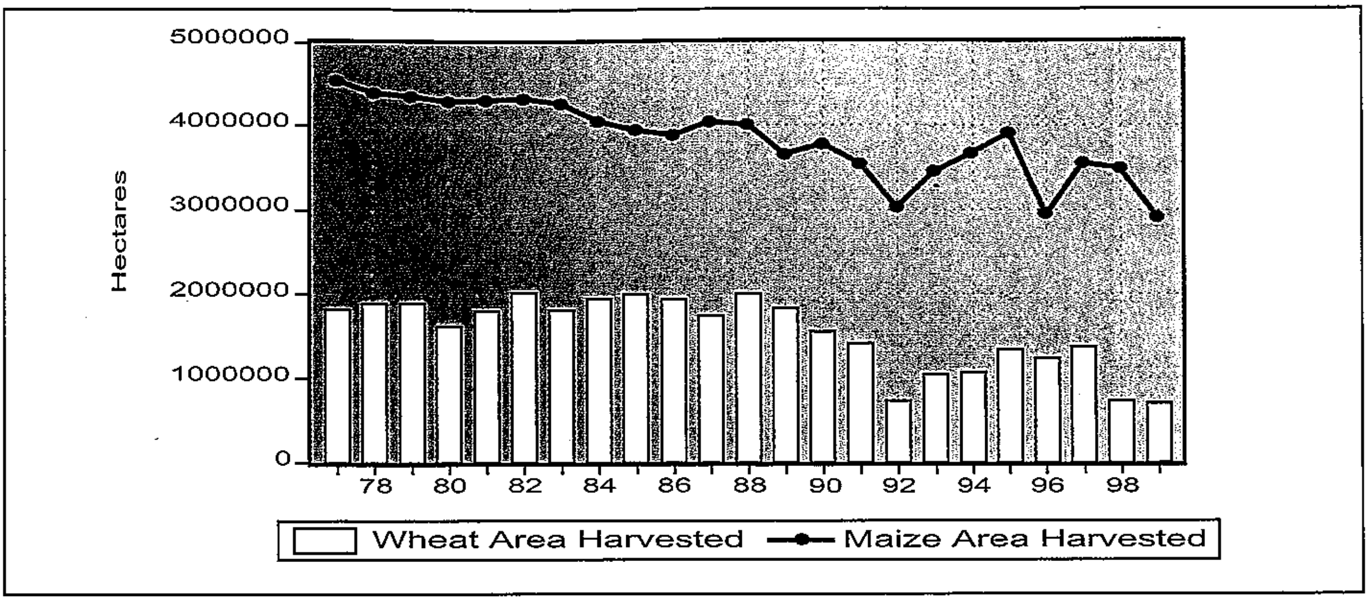

Figure 3. Area harvested of maize and wheat

above graphs is that agricultural production is becoming more efficient in terms of fertilizer use. The lower area planted resulted in higher yields with lower use of fertilizer.

Groenewald (1980) reported that as a group, developed countries experienced increased consumption of nitrogen, but decreased use of both phosphorus and potassium fertilizers. South Africa in fact followed a similar trend between 1977 and 1999. Nitrogen consumption increased by 18,2%, while the consumption of potassium increased by only 1%. Phosphorus consumption on the other hand decreased by 70%. This could be attributed to the conventional static theory of production economics.

Economic conditions influencing agriculture have drastically changed since the sixties. During the sixties, fertilizer prices and fuel prices increased by 0,5 and 0,2% respectively per year, thus increasing much slower than other farm requisites and thus became relatively cheaper (Groenewald 1980). This situation however, in particular for fuel, began to change in the early seventies. The real price of nitrogen has decreased by 21,3%, while the price of phosphorus increased by 66% and potassium increased by 44% in the same period. Producer prices of maize and wheat in real terms have increased despite market deregulation after 1977 (**Figure 4**).

Economic contribution of fertilizer

It has been a common practice to compute the value added (VAD) when evaluating the contribution of fertilizer. There are several ways of calculating this value added ratio. For the purpose of this analysis, the sum of salaries, fuel cost, land rent and machinery (all in current prices) was subtracted from the total gross revenue crop value. This value is then divided by total fertilizer consumption, in terms of plant nutrient tonnage and in

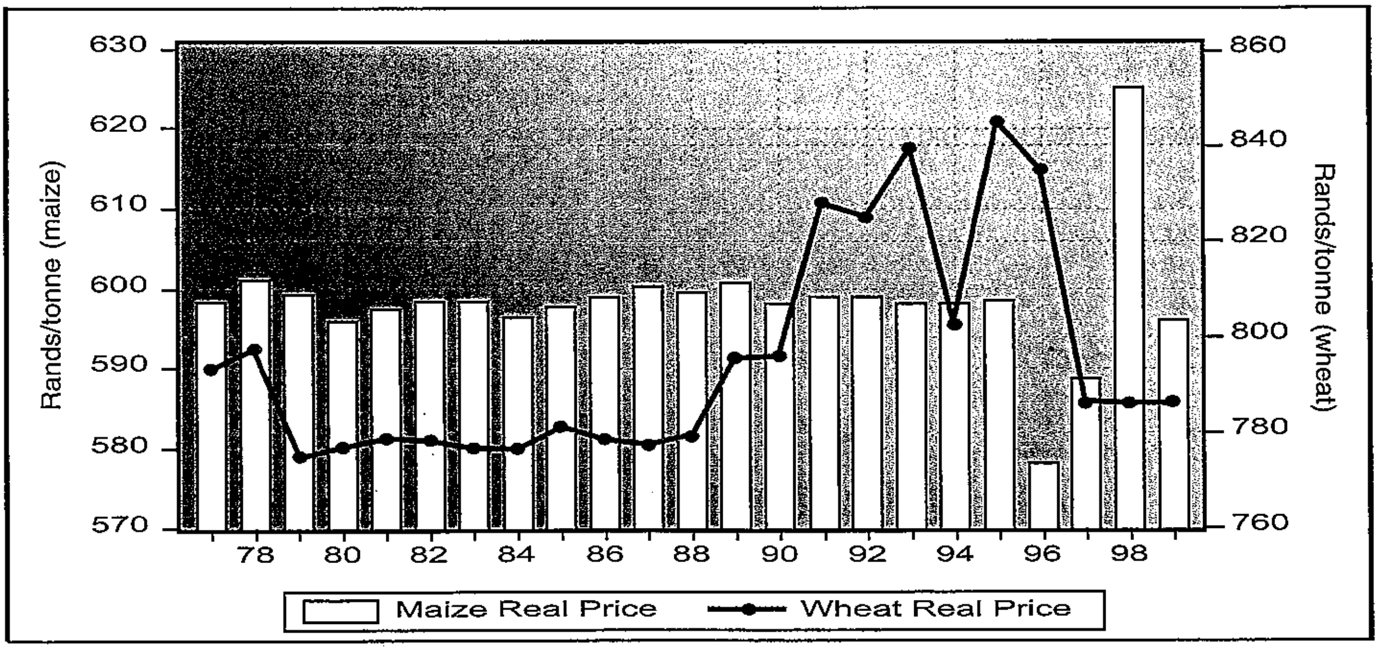

Figure 4. Real maize and wheat prices

physical tonnage for comparative reasons. The value added per ton of fertilizer use value is reported below in **Table 1.** From Table 1, it is evident that the value added has been increasing in nominal terms.

The data used in this case study was compiled from various sources. Actual prices, physical and nutrient tonnage were obtained from the Fertilizer Society of South Africa. Abstract of Agricultural Statistics provided crop data. Where necessary data was cross-checked with different sources such as the FAO agricultural database.

Table 1. Value added in Rands per ton of fertilizer use

	1985	1986	1987	1988	1989
Nutrient Fertilizer	358,9	379,2	815,1	898,3	923,4
Physical Fertilizer	97,6	105,1	220,5	249,4	257,7
	1990	**1991**	**1992**	**1993**	**1994**
Nutrient Fertilizer	1207,8	913,7	1325,4	635,0	1167,0
Physical Fertilizer	343,1	259,8	381,5	184,7	344,7
	1995	**1996**	**1997**	**1998**	**1999**
Nutrient Fertilizer	1145,9	1378,8	1651,4	1276,4	994,7
Physical Fertilizer	337,2	410,0	493,9	399,6	303,2

The low value in 1995 was due to poor rainfall in 1994 and therefore a poor yield in that year. Interesting to note furthermore is that value added in physical tonnage increased more in the years 1985 to 1999 than value added in nutrient tonnage, possibly due to improved technology in fertilizer production.

Estimating the demand for fertilizer

In the literature there are two approaches to estimate fertilizer demand; first is the estimation of a single equation to estimate relative own price elasticities of demand. Relative price is usually defined as the price of fertilizer relative to output. Secondly, based on the duality theory, fertilizer demand elasticities can be estimated in the context of estimating complete elasticity matrices (Meregos and Stoforos, 1997). Burell (1989) reviewed several studies on fertilizer demand and **Table 2** reports the computed elasticities.

Ordinary least square estimation were used to estimate the static demand equation. Both static and dynamic demand equations are in double log form. **Table 3,** reports the estimates of the parameters; in parenthesis is the t-statistics.

All the elasticities have the proper sign and are statistical significant at the required level of significance. Though labour elasticity is not statistical significant but has proper sign and is kept due to its economic contribution in explaining fertilizer use. The time trend variable indicates that with time farmers are becoming more and more efficient in terms of fertilizer use. This argument can further be supported from the above graphs (Figures 1 - 3) showing that the area harvested has been declining but production has been increasing constantly with less fertilizer use.

Table 2. Elasticities of fertilizer demand

Country	Own-Price	Short-Run	Long-Run
UK (1971-1981)	-0,24		
France (1959-1984)	-0,33		
Denmark (1956-1984)	-0,19		
US (1957-1979)	-0,70		
US (1964-1989)		-0,21 to -0,25	-0,31 to -0,41
Greece (1960-90)		-0,36	-0,81

Meregos and Stoforos (1997) reported a short-run own price elasticity of -0,36, and long run own price elasticity of -0,81 for Greece. Denbaly and Vroomen (1993), however, estimated the short-run own price elasticity for the US to be between -0,21 and -0,25, and the long-run elasticity to be between -0,31 and -0,41.

Since farmers operate in a dynamic world in which prices and input-output relationships are not known with certainty, a dynamic demand function is subsequently

Table 3. Static Fertilizer Demand Equation

	FPT	FNT
Constant	15,51238 *(34,2502)**	16,813 *(40,2116)**
Real Crop Price	0,88998 *(1,8934)****	0,65948 *(1,5195)*
Real Price of Fertilizer	-0,40415 *(-4,4756)**	-0,3728 *(-4,1330)**
Real Price of Labour	-0,2223 *(-1,4135)*	-0,2112 *(-1,3933)*
Trend	-1,5368 *(-1,996)****	-1,2690 *(-1,804)****
Adjusted R-Square	0,82	0,87
F-Statistics	13,590	20,47
D.W	1,995	1,803

** 1% level of Significance, ** 5% Significance, *** 10% Significance.*

estimated. **Table 4** reports the estimates of the dynamic demand function for fertilizer.

Fertilizer Market Outlook

Using the elasticities **(Table 5)** in this section we generated the market outlook of fertilizer for South Africa **(Figure 5 and 6).** Based on the assumption that the producer price index, the fertilizer price, labour price index, and the wheat price index continue to follow the same trend, the demand for fertilizer can be forecast as in **Table 6.**

Future Research Work

Though the above elasticities of that factors influencing fertilizer demand have important implication for the agricultural sector, future studies in particular should address the following question: How far would free market prices both for input and output affect agricultural output. Or, how would an increase in fertilizer prices due to the depreciation of the Rand further decrease fertilizer use and how farming sector will adjust, i.e., use of more capital or less land and labour. Another aspect that needs investigation is to examine the nature of crop supply and fertilizer demand function for a within crop season period. Also to better understand fertilizer use the soil type and weather conditions should be included in such studies as these will provide information which will be useful to both the farmer and fertilizer industry.

Table 4. Dynamic Fertilizer Demand Equation

	FPHT	FTC
Constant	12,103 *(1,629)*	9,557 *(1,561)*
Crop Price (-1)	1,1074 *(3,434)**	1,2191 *(2,767)*
Real Price of Fertilizer(-1)	-0,1736 *(-1,378)*	-0,2317 *(-1,566)*
Real Price of Labour(-1)	-0,1359 *(-1,005)*	-0,1693 *(-1,116)*
FPT(-1)	-0,24707 *(-1,356)*	-0,3178 *(-1,220)*
R-Square	0,80	0,77
F-Statistics	11,077	6,1575

Table 5. Elasticities Computed from the Dynamic Demand

	PHYSICAL TONNAGE Short-run	PHYSICAL TONNAGE Long-run	NUTRIENT TONNAGE Short-run	NUTRIENT TONNAGE Long-run
Crop Price	1,107	0,887	1,319	0,9189
Own Price	-0,174	-0,139	-0,232	-0,176
Labour	-0,136	0,109	0,169	-0,129

Table 6. Fertilizer Consumption

COMMODITY	2001	2002	2003	2004	2005
Physical Tonnage	2061607	2048107	2036883	2015302	2004919
Nutrient Tonnage	617133	615353	613584	611828	610087

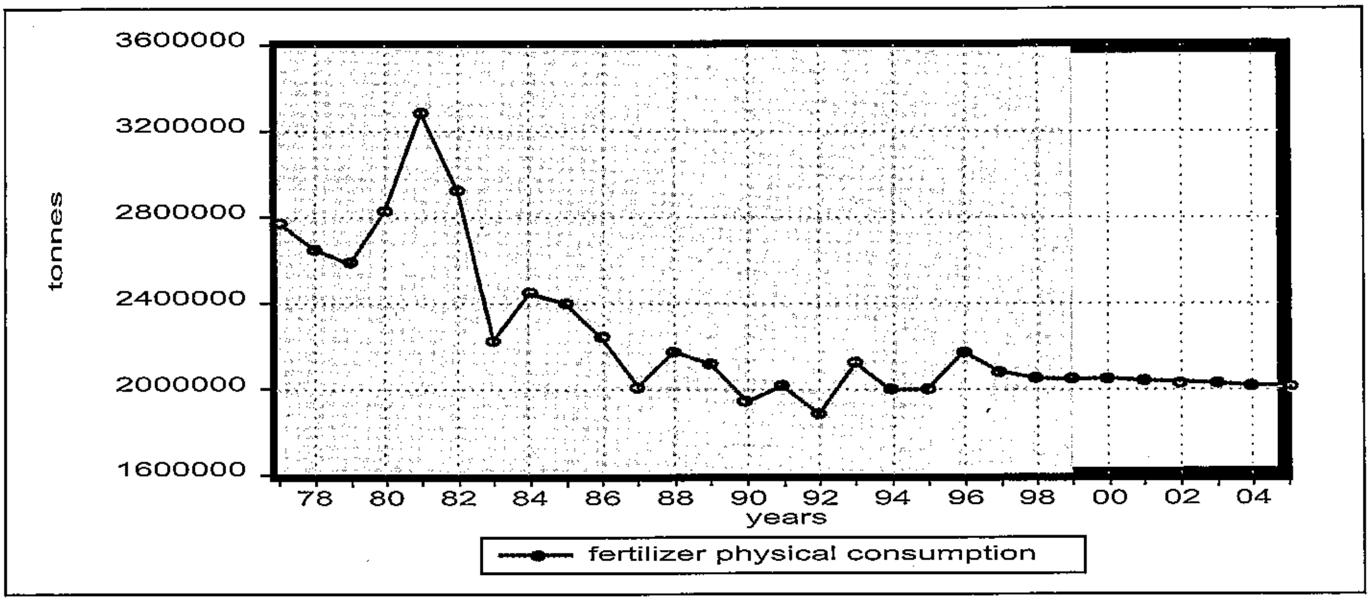

Figure 5. Market outlook until 2005 for fertilizer consumption

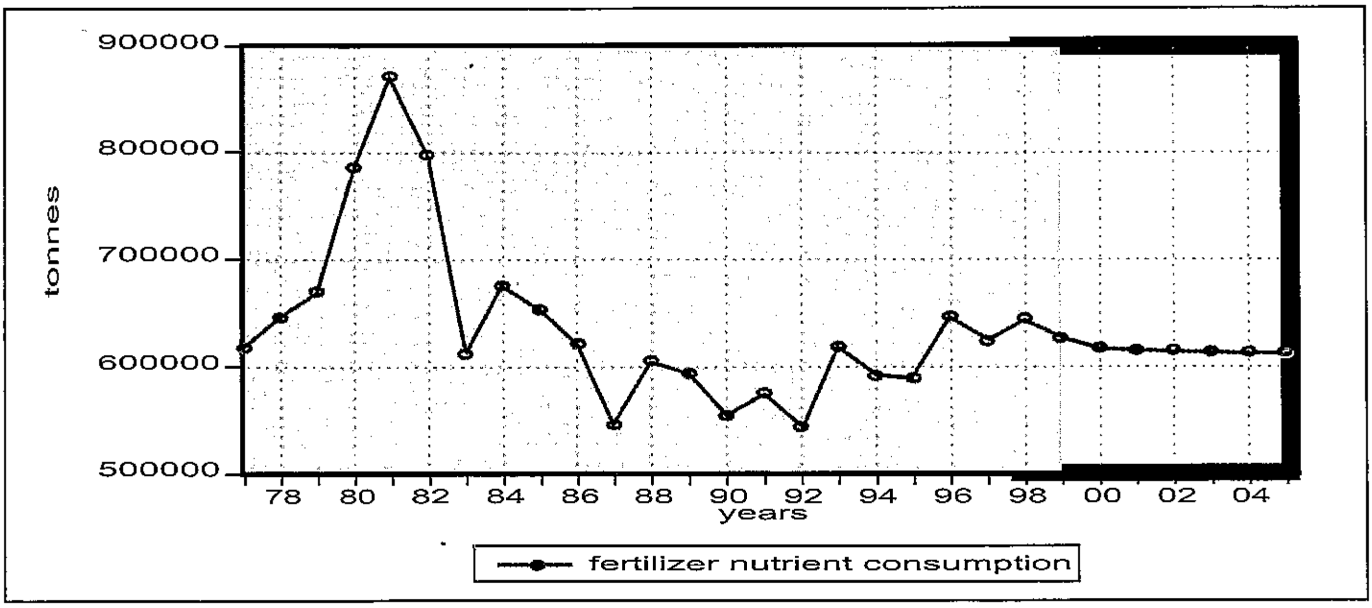

Figure 6. Market outlook for fertilizer nutrient consumption

SUMMARY

This study has generated some useful information about the level of fertilizer use and own-price, output price elasticities. These elasticities have major implications both for the farmer and input sector. From the estimated results it can be said that higher factor prices have contributed to the shift in land out of a specific crop but intensive production have kept production level normal, thus resulting in less input use such as fertilizer, which implies that farmers are becoming efficient in terms of input use.

Also the use of fertilizers will not necessarily increase during the coming years. The challenge is to ensure that this level of fertilizer will increase or keep the same level of agricultural output. The evidence provided by the study is that fertilizer use has been mitigated by an improvement in the efficiency of the fertilizer uses.

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